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Quarantine Tracker

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Abstract

As we all know, the world is still facing a massive number of deaths due to the COVID-19 pandemic. Although governments all over the world have taken measures to slow down the spread of the virus, the number of deaths keep increasing on a large scale. In order to prevent this situation, geofencing technology is used to efficiently track the people under quarantine. Geofencing is a technology in which an app or a software uses Wi-Fi, GPS, or cellular data to trigger an alert whenever a person under quarantine exits the geofence. In this project, we are using the Wi-Fi range of the user's home location to detect whether the user exits the geofence or not. Geofence is set up by using the exact latitude and longitude of the quarantined individual's home location, which creates a virtual circular or rectangular boundary around the user's home location. Whenever the user exits the boundary, an alert will be sent to the server side of the application, which in turn helps the health officials to take the necessary action against the user.

Keywords: Alert, COVID, Geofence, Home, Quarantine, Track, User, Watch

Abbreviations and Acronyms

RSA Algorithm: Rivest-Shamir-Adleman Algorithm

Wi-Fi: Wireless Fidelity

iOS: iPhone Operating System

WHO: World Health Organisation

COVID: Corona Virus Disease

USB: Universal Serial Bus

Introduction

Geofence technology denotes a virtual boundary with a predefined set of boundaries in a geographical area. It is widely used in location-based services and it is called the geofencing technique. It is widely used in Android and iOS systems. Because of the rapid growth and advancement in mobile technologies, geofencing has penetrated many domains and has been applied in various scientific and social applications. It is used to monitor human beings or to monitor a device that enters a particular geographical area. Active geofencing technique is used in smartphone applications to track various location-based services. Another geofencing technique, that is, passive fencing, depends on the Internet connectivity, either through Wi-Fi or cellular data, and is used in services and applications that always work in the background. Location tracking, child monitoring, traffic monitoring, drone monitoring, human resource monitoring, and location-based marketing are a few real-time applications of geofence technology. This technique can be used in a pandemic situation to monitor the movement of people who are entering or exiting an area affected with an epidemic. The geofencing technique is used to track the COVID zones and to trigger an alert message when a person enters/exits the COVID zone.

Related Works

The quarantine tracker is a device that is unique compared to the existing systems that are used for COVID monitoring. The quarantine tracker functions using the geofence technology and Wi-Fi.

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Existing Contact Tracing Technologies

Aarogya Setu App

The Aarogya Setu App is the main contact tracing technology developed in India. Aarogya Setu keeps track of other app users that a person came in contact with. If any of the contacts test positive for COVID-19, then the app alerts the users. The phone's Bluetooth and GPS capabilities are used by the application. It keeps a record of all other app users that it detected nearby, using Bluetooth. However, experts and ethical hackers have raised concerns on the privacy of the application.

HaMagen App

HaMagen is an app that is initiated by the Ministry of Health in Israel. It can tell if a user has been in the presence of anyone who has been diagnosed with coronavirus. The app cross-checks the GPS history of the user's mobile phone with the historical geographic data of patients from the Ministry of Health.

The disquiet about the HaMagen app is that it informs only the user if they were exposed to someone with COVID, and does not inform the government. HaMagen app also uses the Bluetooth connectivity for proximity.

TraceTogether

TraceTogether is a contact tracing technology that the Government of Singapore has implemented, to facilitate contact tracing. The TraceTogether app works by exchanging short-distance Bluetooth signals between phones to detect other participating TraceTogether users in close proximity. It does not collect or use any location data, and it does not access a user's phone contact list or address book. To establish a contact it only uses Bluetooth data and does not store information about where the contact happened.

All these above contact tracing technologies are based on Bluetooth proximity identification. Bluetooth only allows short-range communication. There is a possibility that the Bluetooth connection may be lost in certain situations. Bluetooth technology is less secure compared to other wireless technologies. So, here in quarantine tracker we are using the Wi-Fi of the user's home for efficient tracking.

Existing Systems that Use Geofence for Movement Monitoring

OJOY A1 Smart Watch

OJOY A1 is a smart watch, especially meant for kids. It helps parents keep track of the whereabouts of their child. OJOY A1 smart watch helps the parent to set geofence framework in the application installed in their phone. If the child goes out of the selected geofence then the parents will be notified by the app. The watch uses the QR code for pairing up with the mobile application. Every time a parent opens the app, it will show the live location of the watch. Track History option is also available. SOS button sends an emergency message to the phone, to alert parents about any dangerous situation. The smart watch uses lithium-ion battery.

Tracker Wristbands

Tracker wristbands are used to geofence people under coronavirus quarantine in Hong Kong. The electronic tracker wristbands are used to ensure that people follow strict quarantine rules. The Tracker wristband is printed with a unique serial number and matching QR code. Tracker wristbands pose no privacy concerns as they do not track one's exact location. The wristband uses lithium-polymer battery.

System Overview

We show in Fig. 1 the operation workflow of the quarantine monitoring system. The system consists of a low-cost waterproof watch and a smartphone owned by the confinee. The quarantine tracker watch is provided at the airport to people coming from abroad or from different states or people who have had contact with a COVID-positive person. The watch tracks the location of the user. The watch includes features such as an alert mechanism and Wi-Fi. There is also an application which is available for free. It should be installed in the user's phone. The user should register with the application and sign in to create a geofence of their home location when they reach home. After creating the geofence, the watch tracks whether the user exits the geofence or not by checking whether the user crossed the range of Wi-Fi in their homes. If YES, then an alert is sent to the server side of the application.

The mobile application also contains the contact details of doctors and other health care officials. Data regarding quarantined individuals will be stored in a database on the server side. The data in the database is protected using RSA (Rivest-Shamir-Adleman) algorithm. USB cable chargers are used for charging purposes and normal power banks will be used for the battery backup. If someone tries to breach the quarantine by leaving their home or removing the wristband, the app triggers a warning and alerts the government. The server side will be notified on receiving the alert. Thus, police officials will take action against the user. After successful completion of quarantine, the user will be provided a quarantine-free certificate and the user should return the watch. The aim of the system is to ensure that the person adheres to the quarantine rules.

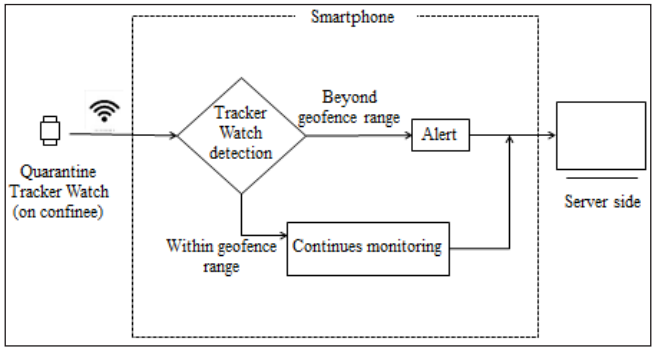

Fig. 1: The Operation Workflow of the Quarantine Monitoring System

Proposed Methodology

The workflow of the proposed methodology is explained in 5 steps. Fig. 2 shows the various processes that will be carried out to track the suspected individuals using geofencing technology. The various steps followed in implementing this methodology in developing an application is explained in the following section.

Step 1: Application Development

A simple mobile application is developed to track the quarantined. The application developed is capable of geofencing the regions and also updates the details of the quarantined passengers to government officials.

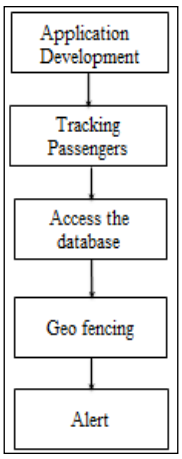

Fig. 2: Process Flow

Step 2: Tracking Passengers

Passengers from the terminals are tracked using a watch in order to ensure their quarantine. This is the next step in this methodology. It tracks the suspicious individuals who might cause the communal spread. These methodologies can be followed to track the individual.

Step 3: Accessing the Database

Access to the database is processed through the RSA algorithm. The RSA algorithm uses 2 key techniques to secure the data. The public key and the private key are used for encryption and decryption, respectively. The data encrypted will be locked using the public key and transformed into a hash file. The required file can be decrypted only when the private key is known. This method secures the data from third-party interruption. Even if it happens, the data hacked will be in hashed form and it takes more than a decade to decode it. Thus, the secured code will be shared only between the 2 groups and the other's key is necessary to get the required data in the original format.

Step 4: Geofencing

Geofencing is a concept of building a virtual boundary around an area. This virtual boundary helps in monitoring the containment zones effectively. Operational costs can be reduced by using an automated system based on

wireless infrastructure. It also helps authorities to catch the violators by sending alerts. Thus, it speeds up the process of inspecting the containment zones and monitoring the individuals who violate the rules laid down by the government.

Step 5: Alert

Alerts are sent during necessary situations, such as when a person tries to break the device or tries to breach the quarantine by leaving the geofence area. These alerting techniques can be utilised to increase the accuracy rate of tracking.

Geofence - Close Proximity Movement

Geofence creates a virtual boundary and binds the person or similar group (family members) within the same compound by defining the fencing radius threshold. Alerts and notifications will be sent to the person whenever they cross the geofence. At this point, no notification is sent to the authority. Fig. 3 shows the close proximity movement of geofence.

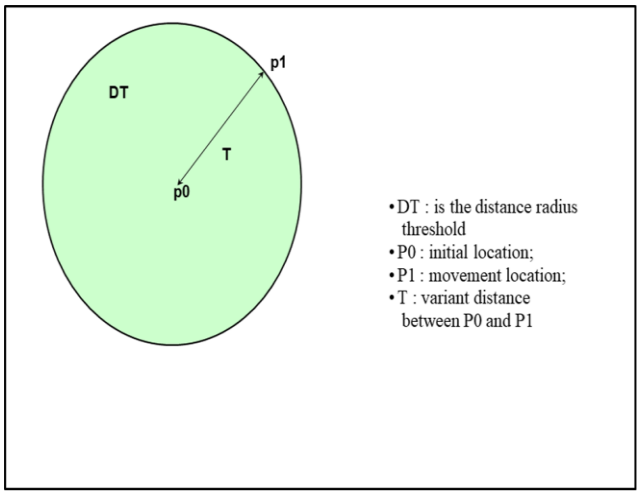

Fig. 3: Close Proximity Movement - Geofence

The algorithm shows the detailed steps in the process of developing a program, based on the equation mentioned in step 5 of the algorithm. To create geofencing based on the x and y coordinates, we should first activate the initial location of the person, denoted as P0, and then movement location of the person, indicated as P1. The validity, denoted as V, if 0, shows that the person has moved out of the geofence area.

Algorithm

Step 1: Start

Step 2: Declare and initialise variables DT and V

Step 3: Enter the value of x and y coordinates of p0

Step 4: Enter the value of x and y coordinates of p1

Step 5: Find value of T

$$T = \sqrt{(x_{P_0} - x_{P_1})^2 + (y_{P_0} - y_{P_1})^2}, \quad (1)$$

Step 6: Check if T <= DT

6.1: if yes, set V as 1

6.2: else, set V as 0

Step 7: Return V and T

Step 8: Stop

If V = 0, then notifications and alerts to be sent to the authorities as the person has moved beyond the geofence**.**

Processing through RSA Algorithm

The process of RSA algorithm that is used in Step 3, accessing the database of process flow (Fig. 2), is shown. Fig. 4 shows the flowchart for the RSA algorithm.

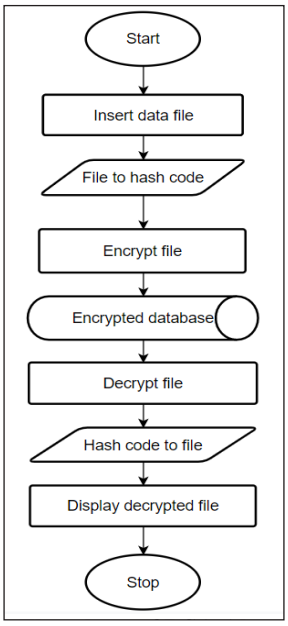

Fig. 4: Flowchart of RSA Algorithm

RSA Algorithm uses certain encryption and decryption mechanisms. Encryption and decryption using the RSA algorithm is done with the help of the public and private key. The algorithm for encryption and decryption is explained in the following section.

Step 1: Choose two prime numbers (p and q)

Step 2: Calculate the value of n and φ, given as

$$n = p \times q \quad (2)$$

$$\varphi = (p - 1) \times (q - 1) \quad (3)$$

Step 3: Find the value of e (public key)

The condition is given as:

$$\gcd(e, \varphi(n)) = 1 \quad (4)$$

Step 4: Compute the value of d (private key)

$$d = e^{-1} \bmod \varphi(n) \quad (5)$$

Step 5: Do encryption and decryption

Encryption is given as:

$$C = M^e \bmod n \quad (6)$$

Decryption is given as:

$$M = C^d \bmod n \quad (7)$$

Results

The quarantine tracker app efficiently tracks the users under quarantine; whenever the user exits the geofence or crosses the Wi-Fi range of their home location an alert is successfully sent to the server side of the application.

Sign Up

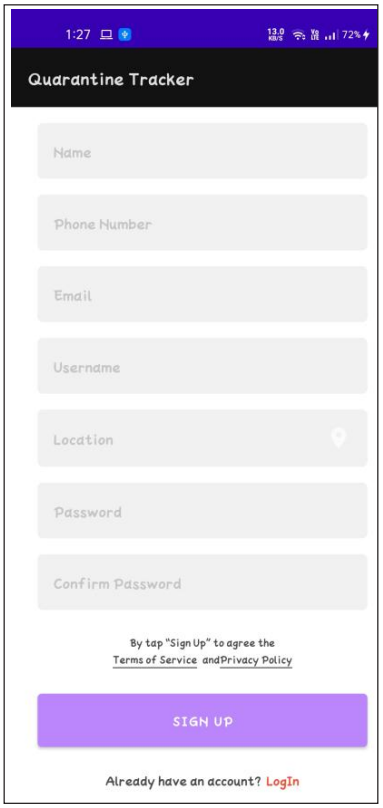

Fig. 5

Map

Fig. 6

Login

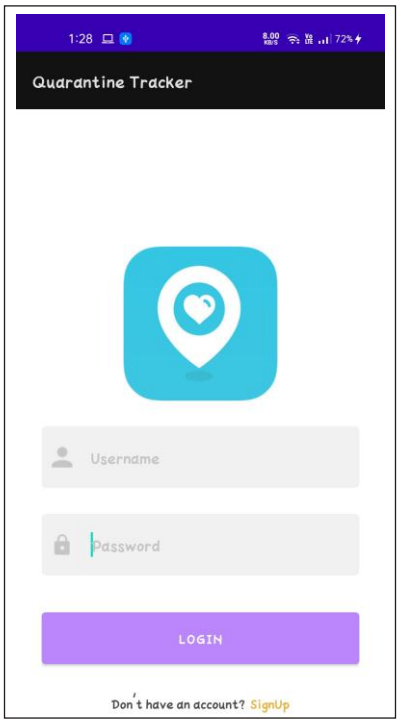

Fig. 7

After Login

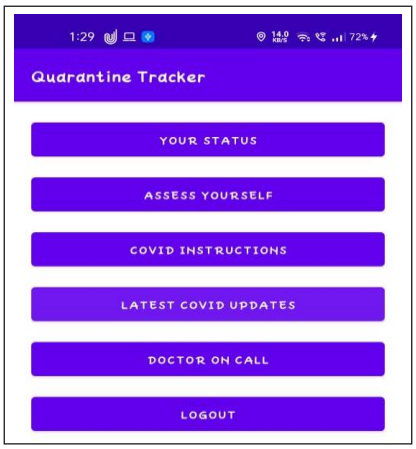

Fig. 8

Assess Yourself

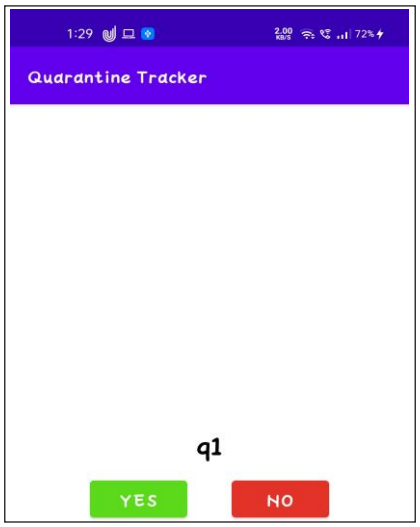

Fig. 9

Result of AssessmenT

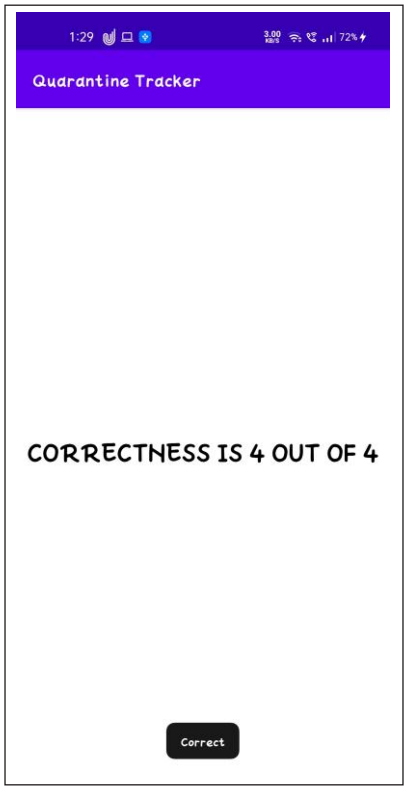

Fig. 10

Your Status

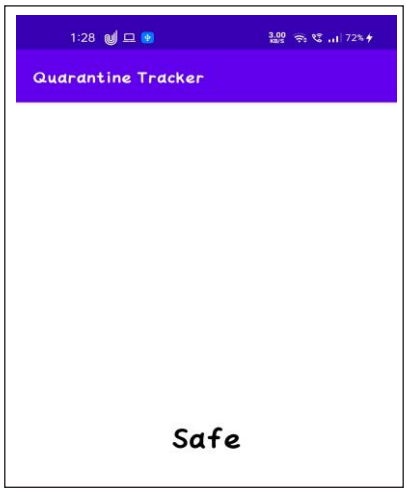

Fig. 11

Covid Instructions

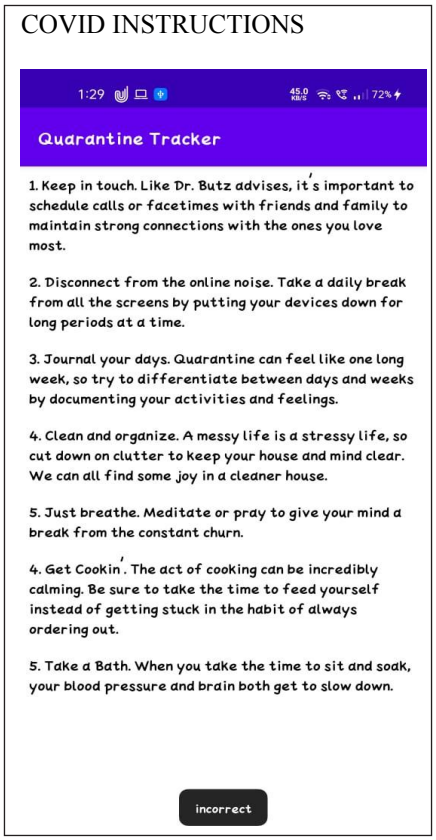

Fig. 12

Latest Covid Updates

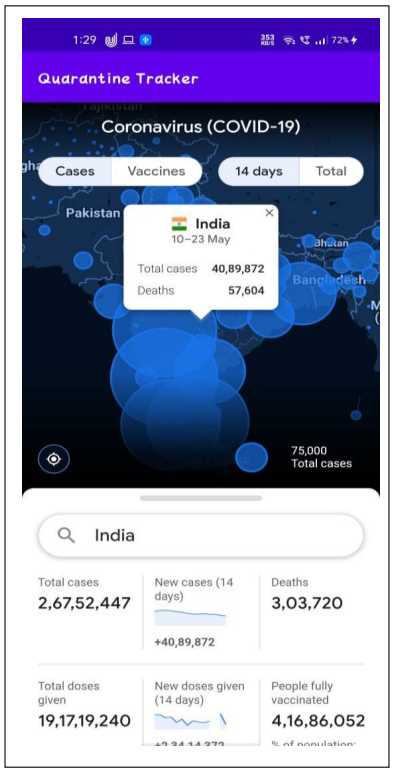

Fig. 13

Doctor on Call

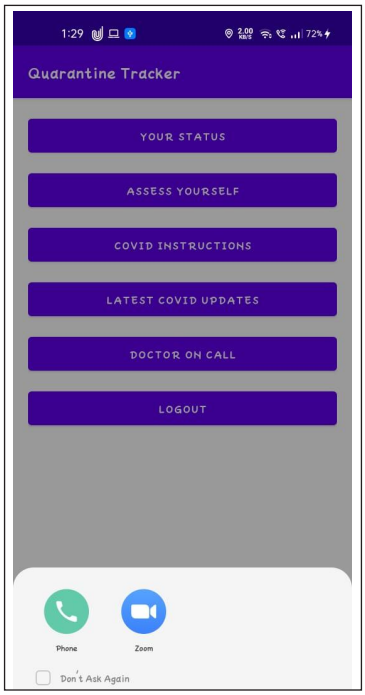

Fig. 14

Database (User Details)

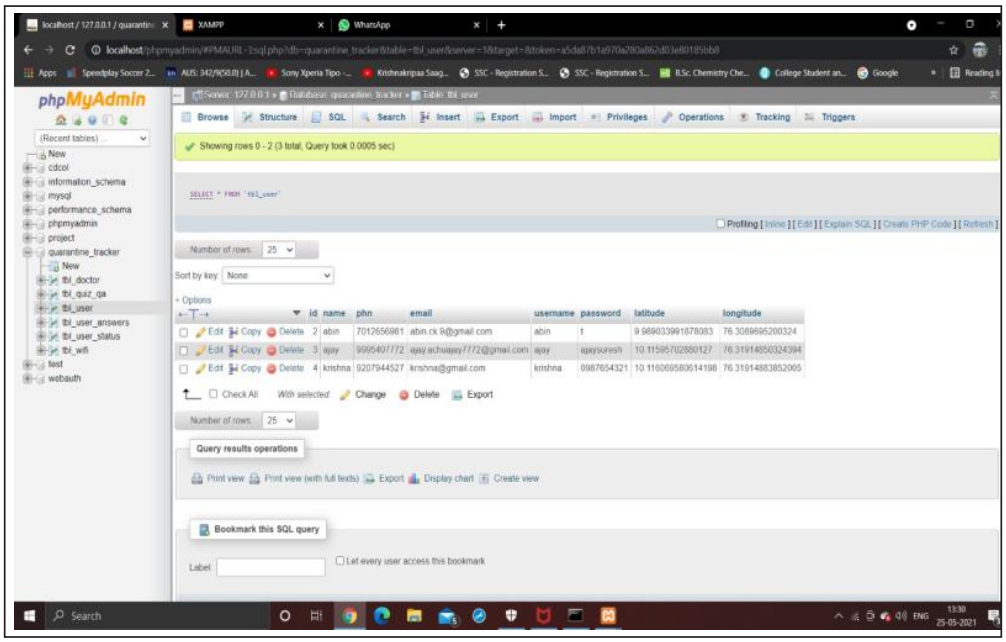

Fig. 15

Database (Wi-Fi Connected)

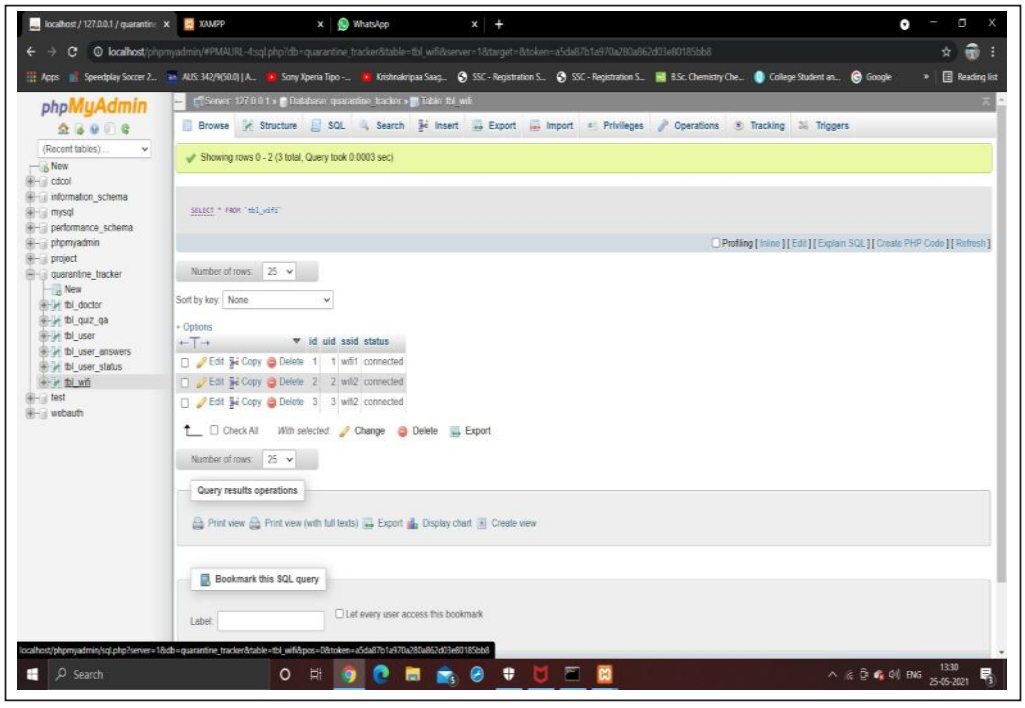

Fig. 16

Database (Wi-Fi Disconnected)

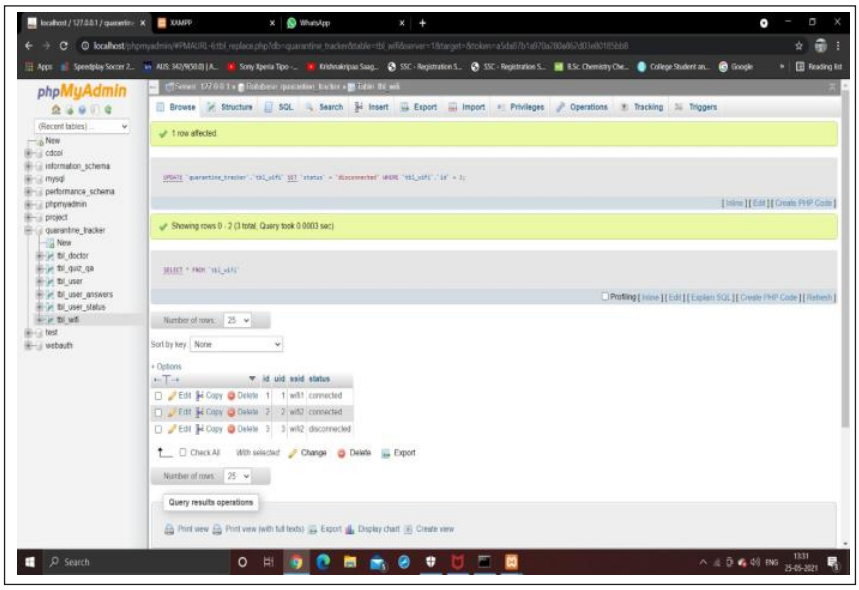

Fig. 17

As shown in Fig. 5, the user registers all their details, such as name, phone number, email, username, location, password, and confirm password. All these details will be saved in the database. Location is set up using the map, as shown in Fig. 6 (latitude and longitude of user's home location) for creating the geofence around the user's home location. Fig. 7 shows the login page; after logging in, a page will occur as shown in Fig. 8. assess yourself is the self-assessment quiz taken by the users, as shown in Fig. 9. There are several questions in this quiz to check whether the person is safe or at risk. Based on the score of the self-assessment quiz, as shown in Fig. 10, your status displays whether the person is safe or not (Fig. 11). Other extra features of this app are the display of COVID instructions (Fig. 12), the latest COVID updates (Fig. 13), and the doctor on call facility (Fig. 14) to be used if the user faces a health emergency.

Fig. 15 represents the user details saved in the database and Fig. 16 and 17 represent the Wi-Fi status of registered users, i.e., whether the Wi-Fi is connected or not. If the Wi-Fi of the tracker watch is disconnected, an alert will be sent to the server side of the application (database). In this way people not following the quarantine can be easily tracked and action can be taken against them.

Conclusion

The proposed methodologies are an effective way to track COVID's communal spread. The workflow of the system needs the required data sets and legal permission to set up the environment that maintains the constitutional law and order in practice. There are several tracking models that are released across the world, such as Aarogya Setu (India), TraceTogether (Singapore), and HaMagen (Israel). All these above discussed contact tracing technologies are based on Bluetooth proximity identification; though Bluetooth proximity identification is helpful for high range in a short distance, the privacy concern is a disputable one. Using modern technology, it is so easy to track the individual gadgets and with Bluetooth enabling, it makes things even worse. Therefore, geofencing with Wi-Fi is the best technology to efficiently track the people under quarantine.

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